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Estimation of Rationed and Unrationed Household Labor Supply Equations Using Flexible Functional Forms

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Abstract

Models of household labor supply are usually estimated using data on households where both male and female partner work in a paid job, with correction for selection bias. From an econometric viewpoint, this approach is unsatisfactory, as a usually large proportion of the available data (the one earner families) is not used in the estimation. In this paper a household labor supply model is estimated using data on both one earner and two earner families, and using flexible functional forms (i.c. the AIDS-specification). Since in this case there exists no explicit closed form for the rationed male labor supply equation (i.e. the male labor supply equation which applies to families with a non-participating female), numerical methods are used. For comparison, the model is also estimated using data on one earner families only and data on two earner families only.

1. Introduction

A distinctive feature of models of female labor supply is the mixed discrete-continuous nature of the dependent variable. As long as the female labor supply decision is analyzed in isolation, it is of minor consequence for the estimation method whether the labor supply (or leisure demand) equation is derived within a utility maximization framework or not. In both cases Tobit-like methods are the appropriate tools for the estimation of the model. A number of authors have estimated models of female labor supply along these lines, e.g. Heckman (1974), Hausman (1980) and Zabalza (1983). However, if female labor supply is analyzed jointly with other household decision variables such as male labor supply or commodity demands, both modelling and estimation within a utility maximization framework becomes more complicated.

One of the main reasons for this complication is that one has to derive equations that give optimal demands for all goods and male leisure if the female partner does not work. As has been shown by Deaton and Muellbauer (1981), the class of utility or cost functions for which these conditional or rationed demand equations can be derived explicitly, is quite restrictive.

In Blundell and Walker (1982), one of the few studies in which male and female labor supply are modelled simultaneously, this problem is avoided by only using observations where both male and female partner are working and by correcting for selection bias. In that case the rationed demand for equations need not be derived and consequently flexible specifications can be used.

However, from an econometric viewpoint this approach is unsatisfactory as a usually large proportion of the available data (the one earner families) is not used in estimation. Moreover, it is possible that parameter estimates based on data on two earner families only do not apply to one earner families because of factors not captured by the model.

In this paper we show that it is not necessary to derive an explicit closed form for the rationed demand functions to estimate all parameters of the model using data on both one earner and two earner families. Hence, using flexible functional forms and using data on both one earner and two earner families is not as incompatible as is sometimes suggested in the literature.

In section 2 we introduce Deaton and Muellbauer's Almost Ideal Demand System (AIDS) as our choice of functional form for the description of household labor supply and we briefly discuss the theory of rationing within the

AIDS-framework. In section 3 the stochastic specification of the model is presented with the corresponding likelihoods. The data is described in section 4. Estimation results are given in section 5. Section 6 concludes.

2. AIDS and Rationing

2.1. AIDS

As a specification of the model we choose the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980a, 1980b). Within a labor supply context it has been used before by Ray (1982). The AIDS cost function has the following form

$$C(u,w_m,w_f,p) = \exp(a+u.b) \tag{2.1}$$

where

$$\begin{aligned} a = {} & \alpha_0 + \alpha_m \log w_m + \alpha_f \log w_f + \alpha_y \log p + \\ & + \frac{1}{2}\gamma_{mm} \log^2 w_m + \gamma_{mf} \log w_m \log w_f + \gamma_{my} \log w_m \log p \\ & + \frac{1}{2}\gamma_{ff} \log^2 w_f + \gamma_{fy} \log w_f \log p \\ & + \frac{1}{2}\gamma_{yy} \log^2 p\ , \end{aligned} \tag{2.2}$$

$$b = \beta_0\, w_m^{\beta_m}\, w_f^{\beta_f}\, p^{\beta_y} \tag{2.3}$$

and

$$\alpha_y = 1 - \alpha_m - \alpha_f \tag{2.4}$$

$$\beta_y = -\beta_m - \beta_f$$

$$\gamma_{my} = -\gamma_{mm} - \gamma_{mf} \tag{2.5}$$

$$\gamma_{fy} = -\gamma_{ff} - \gamma_{mf} \tag{2.6}$$

$$\gamma_{yy} = -\gamma_{my} - \gamma_{fy} \tag{2.7}$$

w_m and w_f are the male and female wage rate respectively, measured after taxes and p is the price of consumption y. The α's, β's and γ's are parameters. Since the this cost function is quadratic in the logs of prices it can serve as a local second order approximation to an arbitrary cost function. Hence, the AIDS cost function has a so-called flexible form.

As is well-known, the unrationed compensated demand for leisure functions can be found by differentiating the cost function with respect to w_m and w_f. The unrationed uncompensated demand functions are found by solving u from

$$w_m T + w_f T + \mu \equiv Y = \exp(a+u.b) \tag{2.8}$$

(where μ is unearned family income (e.g. property income or welfare benefits) and T is the total number of hours per period of time; Y is full income) and substituting the solution for u into the unrationed compensated demand functions.

This leads to the following specifications for the AIDS uncompensated unrationed demand for leisure functions:

$$\ell_m = (Y/w_m)(\alpha_m+\gamma_{mm} \log w_m+\gamma_{mf} \log w_f+\gamma_{my} \log p+\beta_m \log Y-\beta_m.a) \tag{2.9}$$

$$\ell_f = (Y/w_f)(\alpha_f+\gamma_{mf} \log w_m+\gamma_{ff} \log w_f+\gamma_{fy} \log p+\beta_f \log Y-\beta_f.a) \tag{2.10}$$

where ℓ_m and ℓ_f are male and female leisure respectively.

2.2. Rationing

The rationing theory employed here has been developed by Neary and Roberts (1980) and Deaton and Muellbauer (1980a, 1981). Let us consider the case where female leisure ℓ_f is restricted to be equal to $\bar{\ell}_f$. Then the rationed cost function for the household is defined as

$$C^R(u,w_m,w_f,p,\bar{\ell}_f) = \min_{y,\ell_m} (w_m\ell_m+w_f\bar{\ell}_f+p.y \mid v \geq u) , \tag{2.11}$$

where $v(\ell_m,\ell_f,y)$ is the direct household utility function defined on male and female leisure and total household consumption.

There is a well-known relationship between the rationed and unrationed cost function:

$$C^R(u,w_m,w_f,p,\bar{\ell}_f) = C(u,w_m,\bar{w}_f,p) + \bar{\ell}_f(w_f-\bar{w}_f) \ , \tag{2.12}$$

where $\bar{w}_f$ is the female wage rate which would induce the household to choose $\ell_f = \bar{\ell}_f$ if there were no rationing.

The rationed compensated demand for male leisure function is obtained by differentiating the restricted cost function with respect to w_m. In view of (2.12) this yields

$$\frac{\partial C^R}{\partial w_m} = \frac{\partial C(u,w_m,\bar{w}_f,p)}{\partial w_m} + \frac{\partial C(u,w_m,\bar{w}_f,p)}{\partial \bar{w}_f} \cdot \frac{\partial \bar{w}_f}{\partial w_m} - \bar{\ell}_f \cdot \frac{\partial \bar{w}_f}{\partial w_m}$$

$$= \frac{\partial C(u,w_m,\bar{w}_f,p)}{\partial w_m} + \bar{\ell}_f \frac{\partial \bar{w}_f}{\partial w_m} - \bar{\ell}_f \frac{\partial \bar{w}_f}{\partial w_m} =$$

$$= \frac{\partial C(u,w_m,\bar{w}_f,p)}{\partial w_m} \tag{2.13}$$

This is just the unrestricted compensated demand at $w_f = \bar{w}_f$. Let $\bar{a}$ and $\bar{b}$ be defined by (2.2) and (2.3) with w_f replaced by $\bar{w}_f$. The uncompensated restricted demand for male leisure function is found by solving u from

$$Y = \exp(\bar{a}+u.\bar{b}) + \bar{\ell}_f(w_f-\bar{w}_f) \tag{2.14}$$

and next substituting the solution for u into the rationed compensated demand function obtained from (2.13).

We will be particularly interested in the case $\bar{\ell}_f = T$, i.e., when the female does not have a paid job. In that case we can rewrite (2.14) as

$$\bar{Y} = \exp(\bar{a}+u.\bar{b}) \ , \tag{2.15}$$

where

$$\bar{Y} = Y - T(w_f-\bar{w}_f) = T.\bar{w}_f + T.w_m + \mu \tag{2.16}$$

Notice that $\bar{Y}$ would be full income if the female wage rate were equal to $\bar{w}_f$. We already know that the rationed compensated demand is equal to the unrationed compensated demand with w_f replaced by $\bar{w}_f$. From (2.15) it is clear that we obtain the rationed uncompensated demand from the unrationed uncompensated demand if we replace w_f everywhere by $\bar{w}_f$ and Y by $\bar{Y}$. So, for example, the restricted demand for male leisure ℓ_m^R is obtained from (2.9) as

$$\ell_m^R = (\bar{Y}/w_m)(\alpha_m+\gamma_{mm} \log w_m+\gamma_{mf} \log \bar{w}_f+\gamma_{my} \log p+\beta_m \log \bar{Y}-\beta_m.\bar{a}) \quad (2.17)$$

Using (2.10) it is also clear that $\bar{w}_f$ must satisfy:

$$T = (\bar{Y}/\bar{w}_f)(\alpha_f+\gamma_{mf} \log w_m+\gamma_{ff} \log \bar{w}_f+\gamma_{fy} \log p+\beta_f \log \bar{Y}-\beta_f.\bar{a}). \quad (2.18)$$

It follows from the analysis by Neary and Roberts (1980) that if the parameters of the AIDS specification are such that the direct utility function v is quasi-concave, there will exist a $\bar{w}_f > w_f$ satisfying (2.18) for any $\bar{\ell}_f$ in the domain of v. In contrast with the essentially linear specification used by, for example, Deaton and Muellbauer (1981) and Blundell and Walker (1982), with AIDS there does not exist an explicit solution for $\bar{w}_f$. Therefore, in the estimation of the model, numerical methods will be used.

As a final note, observe that in the general case where $\bar{\ell}_f$ is not necessarily equal to T, $\bar{Y}$ is defined as

$$\bar{Y} = Y - \bar{\ell}_f(w_f-\bar{w}_f) = (T-\bar{\ell}_f).w_f + \bar{\ell}_f.\bar{w}_f + T.w_m + \mu . \quad (2.19)$$

Here $(T-\bar{\ell}_f).w_f$ is the amount of money earned by the female partner in market work. Since $\bar{w}_f$ is the shadow price of female leisure, $\bar{w}_f.\bar{\ell}_f$ is the value to the household of the female leisure. So $\bar{Y}$ is the subjectively valued full income in the case of rationing. Observe that in the unrationed case $\bar{w}_f = w_f$ so that the subjective value of female leisure is $\ell_f.w_f$. Since $\bar{w}_f > w_f$, we have that $\bar{Y} \leq Y$ with equality holding when there is no rationing.

3. Estimation

The only form of rationing considered in estimation is the case where the female partner attains the maximal amount of leisure, i.e., she does not have a paid job. In that case she is rationed at $\bar{\ell}_f = T$. We shall estimate a model of joint labor supply of the male and the female partner in a household and of total consumption. As always, the budget constraint (in this case the full income constraint) allows us to drop one equation. We have chosen to omit the demand for total consumption equation so that we are left with a system of two labor supply equations (or, equivalently, demand for leisure equations) for the male and female partner.

Let us introduce the following notation with respect to the i-th household:

$i \in \theta_1$ if both partners work;

$i \in \theta_0$ if only the male partner works.

The functional form of the male labor supply changes if a household switches from regime θ_1 to regime θ_0. So we have the following system:

$$\ell_f^* = g_f(w_m, w_f, p, \mu) \tag{3.1}$$

$$\ell_f = \ell_f^* \text{ if } \ell_f^* < T \tag{3.2}$$

$$\ell_f = T \quad \text{if } \ell_f^* \geqslant T \tag{3.3}$$

$$\ell_m = g_m(w_m, w_f, p, \mu) \text{ , if } \ell_f^* < T \tag{3.4}$$

$$\ell_m^R = g_m^R(w_m, \bar{w}_f, p, \mu) \text{ , if } \ell_f^* \geqslant T \tag{3.5}$$

where g_f and g_m are the unrestricted AIDS female and male demand for leisure equations, respectively; g_m^R is the restricted AIDS male demand for leisure equation. A stochastic specification for this system is obtained by adding error terms ε_f, ε_m, ε_m^R to the share form of equations (3.1), (3.4) and (3.5), respectively.[1)] The error terms ε_f, ε_m, ε_m^R are assumed to follow a normal distribution with zero mean and unrestricted variance covariance matrix.

The normality assumption is primarily made for convenience. It can only be approximately true since all endogenous variables have a limited range. The covariance between ε_m and ε_m^R cannot be estimated, because there are no observations for which we can observe ℓ_m and ℓ_m^R jointly.

In principle, the parameters of the model can be estimated on three types of data.

Case I

Data on both θ_0 and θ_1 are used. The likelihood of the observations is then:

$$L_1 = \prod_{i \in \theta_1} h_1(s_f^{*i}, s_m^i) \prod_{i \in \theta_0} \int_{\tilde{T}}^{\infty} h_2(s_f^{*i}, s_m^{R^i}) ds_f^{*i} , \tag{3.6}$$

where s_f^*, s_m and s_m^R are the budget shares corresponding to ℓ_f^*, ℓ_m and ℓ_m^R, respectively and $\tilde{T}$ is defined as $\tilde{T} = T.w_f/Y$. h_1 is the joint density of s_f^{*i} and s_m^i and h_2 is the joint density of s_f^{*i} and $s_m^{R^i}$. Both densities are marginals of the joint density of s_f^{*i}, s_m^i and $s_m^{R^i}$.

Case II

Only data on θ_1 are used. The likelihood of the observations is

$$L_2 = \prod_{i \in \theta_1} h_1(s_f^{*i}, s_m^i) \Big/ \int_{-\infty}^{\tilde{T}} h_3(s_f^{*i}) ds_f^{*i} , \tag{3.7}$$

where h_3 is the marginal density of s_f^{*i}.

Case III

Only data on θ_0 are used. The likelihood of the observations is

1) We do not allow explicitly for random preferences at the present stage. This extension remains an important goal for future research. An econometric model of consumption behavior allowing for rationing and random preferences has been estimated by Lee and Pitt (1983). However, they only consider rationing at zero quantities, which simplifies their analysis considerably.

$$L_3 = \prod_{i \in \theta_0} \int_{\tilde{T}}^{\infty} h_1(s_f^{*i}, s_m^i) ds_f^{*i} \Bigg/ \int_{\tilde{T}}^{\infty} h_3(s_f^{*i}) ds_f^{*i} \qquad (3.8)$$

We estimate the paramaters in the model (3.1)-(3.5) for each of these three cases. These likelihoods are maximized using a quasi-Newton algorithm which requires no (analytical) derivatives, as provided by computer routines of the NAG-Library (EØ4JBF). For Cases I and III, equation (2.18) has to be solved numerically for all elements of θ_0, for all evaluations of the likelihood function, needed to attain the global maximum of the likelihood and to calculate the estimated (asymptotic) variance-covariance matrix of the maximum likelihood estimaters. The technique used is a combination of the methods of linear interpolation, linear extrapolation and bisection (NAG-library, CØ5AZF). Although concavity of the cost function and hence unicity of $\bar{w}_f$ can not be guaranteed for all elements of θ_0, we always found a unique $\bar{w}_f$ each time equation (2.18) was solved.

4. The data

The models in section 3 have been estimated using data from a labor mobility survey in the Netherlands, conducted in the Fall of 1982 by the Netherland Central Bureau of Statistics and the Institute for Social Research of Tilburg University. The sample has been drawn randomly from the population of all households in the Netherlands whose head is between 18 and 65 years of age; it contains 1315 households.

From this sample we took a subsample of households containing at least two adults of different sex, where the male partner is an employed wage earner. The size of the subsample is 507; in 197 households the female partner is also an employed wage earner, in 310 households the female partner does not have a paid job. Thus, we excluded the self-employed, the households with only one adult, the households where the male partner is unemployed, retired, going to school, disabled, etc.

To be able to estimate model (3.1)-(3.5) we need observations on (potential) wage rates, also of females who did not have a paid job at the time of the survey. We followed the standard procedure of constructing a wage equation for females on the basis of the households for which we observe the female wage rate. In our sample, this is only the case for the 139 households where the female partner works at least 15 hours a week.

Using Heckman's procedure to correct for selectivity bias, the following wage equation was estimated (t-values in parentheses):

$$\begin{aligned} w_f = \underset{(0.36)}{2.14} + \underset{(0.63)}{0.26}\ AGE - \underset{(-0.74)}{0.003}\ AGE^2 + \underset{(1.32)}{1.68}\ DUM_1 + \\ \underset{(2.78)}{2.12}\ DUM_2 + \underset{(1.23)}{3.01}\ DUM_3 + \underset{(1.34)}{1.69}\ \hat{\lambda}\ ,\ R^2 = 0.14 \end{aligned}$$

DUM_1, DUM_2 and DUM_3 are dummy variables to represent education, $\hat{\lambda}$ is the estimated inverse of the Mill's-ratio (see Heckman (1979)).

In the estimation of the model the predicted values (with omission of $\hat{\lambda}$) for both participating and non-participating females were used as an instrument for female wage rate.

5. Results

The model has been estimated for the three cases distinguished in section 3. In addition, for case I (data on both rationed and unrationed households are used) the model has been re-estimated for subsamples that are homogeneous with respect to family size.

5.1. No family size effects

The results of the ML-estimation for the three cases are summarized in table 1. Comparison of the parameter estimates across columns suggests that the three different cases do not yield dramatically different results. The estimates obtained in case I are the most accurate ones, because more observations are used than in the other two cases. The standard errors in case III are much larger than in cases I and II. This is due to the fact that in case III (data on one earner families only) there is no variation in female labor supply.

Although likelihood ratio tests of the equality of parameters across columns reject the equality hypothesis,[1] drawing the labor supply functions implied by the parameter estimates yield similar results. See figure 1.

1) The estimates of the α's, β's and γ's of each case were inserted in the likelihood functions of all other cases. In all (six) cases the resulting test statistic implied rejection at the 5%-level of the equality hypothesis.

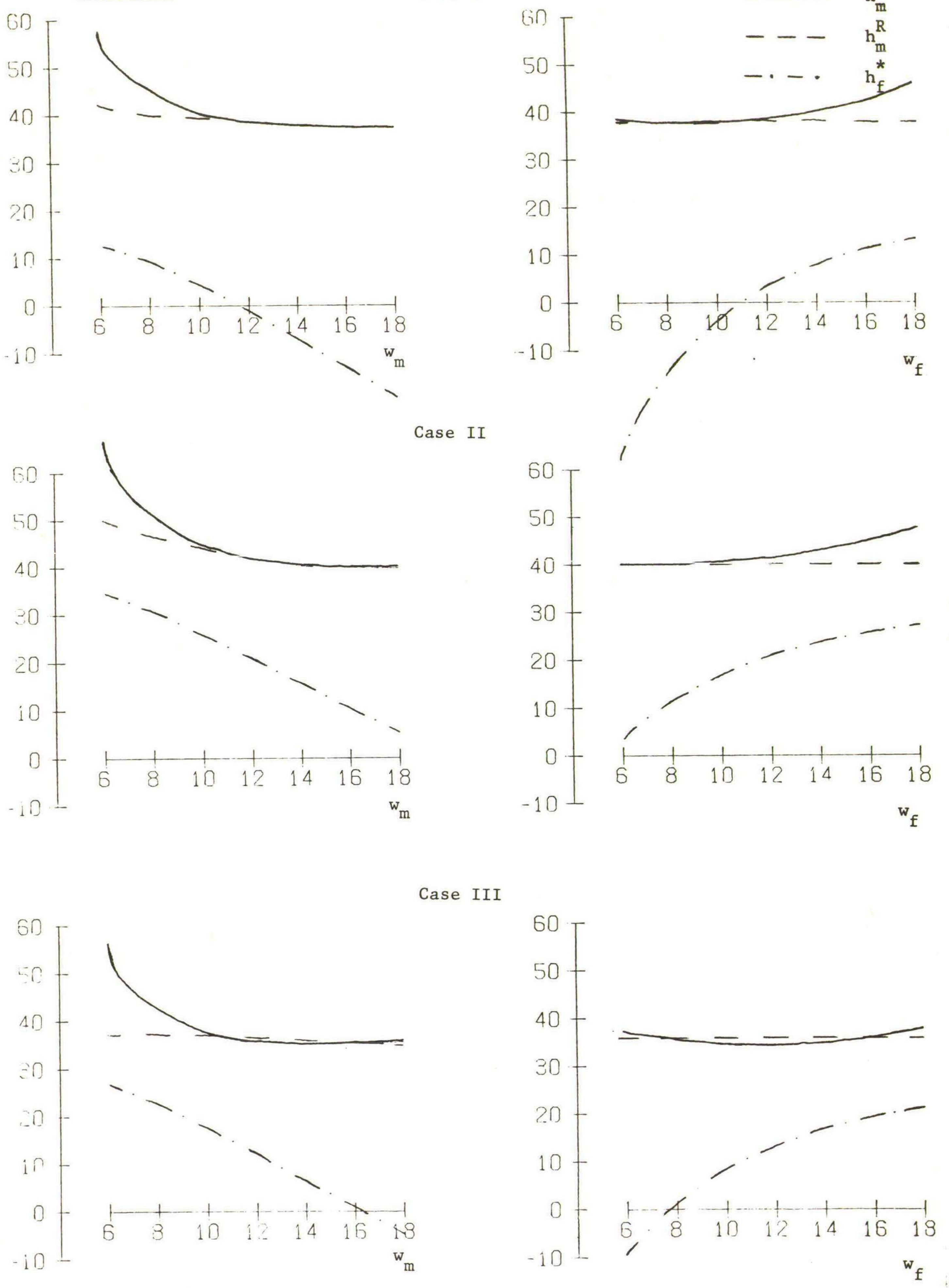
Table 1. Estimation results[a] (asymptotic standard errors in parentheses).

Parameters	Case I	Case II	Case III
α_m	0.64 (0.021)	0.69 (0.023)	0.69 (0.122)
α_f	0.35 (0.052)	0.27 (0.065)	0.31 (0.222)
γ_{mm}	0.11 (0.010)	0.10 (0.013)	0.10 (0.112)
γ_{mf}	-0.11 (0.017)	-0.11 (0.021)	-0.12 (0.119)
γ_{ff}	0.11 (0.028)	0.15 (0.026)	0.15 (0.208)
β_m	-0.86 (0.092)	-0.90 (0.116)	-0.97 (0.575)
β_f	0.37 (0.059)	0.17 (0.090)	0.19 (0.373)
σ_m	0.026 (0.0017)	0.024 (0.0012)	-
σ_f	0.065 (0.0036)	0.036 (0.0026)	-
σ_m^R	0.028 (0.0020)	-	0.033 (0.0010)
$\rho(\varepsilon_m;\varepsilon_f)$ [b]	0.28 (0.110)	-0.09 (0.009)	-
$\rho(\varepsilon_m^R;\varepsilon_f)$ [b]	-0.68 (0.138)	-	-0.84 (0.287)
log L	1236.9	887.1	711.7
number of observations	507	197	390

a) α_0 was fixed a priori for computational reasons (see Deaton and Muellbauer (1980b) and Ray (1982).

b) ρ stands for the correlation coefficient.

Figure 1



The male labor supply functions is backward bending in the lower ranges of w_m and forward bending for high values of w_m. Male labor supply is rather inelastic, both with respect to w_f and w_m. Apart from the familiar interpretation that substitution and income effect cancel out more or less, this finding may also point at institutional constraints which keep most males at a 40-hour work week. Notice that h_m^R tends to be even less elastic with respect to w_m in rationed families, where the female does not have a paid job. These appear to be the traditional families where the female does not work and the male has a full-time (= 40 hours a week) job. Note that h_m^R is perfectly inelastic with respect to w_f, as it should be.

Female labor supply is more responsive than male labor supply to both the male and the female wage rate. If the male wage rate goes up, female labor supply falls. If the female wage rate rises, female labor supply rises as well. The only clear difference between the three cases is that for case II (only two earner families) h_f^* is higher at any given female wage rate than for cases I all families used or III (only one earner families). This suggests that using the (relatively small) truncated sample of two earner families only may lead to bias. However, so far we have ignored the effects of family composition. The distribution of family sizes is different in the three cases so the differences may simply be due to the omitted family size factor.

Table 2. Estimation results case I for different family sizes (asymptotic standard errors in parentheses).

Parameters (Family size)	N = 2	N = 3	N = 4	N ⩾ 5	All households[1)]
α_m	0.52 (0.059)	0.66 (0.152)	0.67 (0.023)	0.50 (0.033)	0.64 (0.021)
α_f	0.51 (0.110)	0.12 (0.101)	0.33 (0.044)	0.64 (0.067)	0.35 (0.052)
γ_{mm}	0.17 (0.017)	0.05 (0.106)	0.13 (0.015)	0.21 (0.010)	0.11 (0.010)
γ_{mf}	-0.16 (0.015)	-0.01 (0.098)	-0.15 (0.024)	-0.22 (0.010)	-0.11 (0.017)
γ_{ff}	0.11 (0.031)	0.04 (0.126)	0.18 (0.035)	0.17 (0.023)	0.11 (0.028)
β_m	-0.53 (0.334)	-0.62 (0.249)	-0.97 (0.166)	-0.55 (0.179)	-0.86 (0.092)
β_f	0.03 (0.183)	0.47 (0.144)	0.29 (0.102)	-0.11 (0.182)	0.37 (0.059)
σ_m	0.013 (0.0010)	0.028 (0.0048)	0.031 (0.0030)	0.027 (0.0037)	0.026 (0.0017)
σ_f	0.050 (0.0040)	0.050 (0.0089)	0.054 (0.0052)	0.043 (0.0065)	0.065 (0.0036)
σ_m^R	0.035 (0.0047)	0.012 (0.0013)	0.025 (0.0015)	0.029 (0.0025)	0.028 (0.0020)
$\rho(\varepsilon_m;\varepsilon_f)$	0.08 (0.217)	-0.09 (0.258)	0.05 (0.120)	0.20 (0.158)	0.28 (0.110)
$\rho(\varepsilon_m^R;\varepsilon_f)$	0.11 (0.158)	0.21 (0.387)	0.36 (0.316)	-0.90 (0.042)	-0.68 (0.138)
Log L	432.5	204.9	427.9	288.2	1236.9
Number of observations	118	75	190	124	507

1) First column table 1.

In table 2 we give the estimation results for case I for subsamples with equal numbers of family members. Now the columns show some clear differences, especially with respect to β_f. A likelihood ratio test of the equality of parameters across subsamples decisively rejects the equality hypothesis.[1)] Figure 2 depicts the labor supply functions of families of different size implied by these estimates.

1) The test statistic (233.2) follows a χ^2-distribution with 36 degrees of freedom. $\chi^2_{095}(36) < \chi^2_{0.95}(40) = 55.76$.

Figure 2

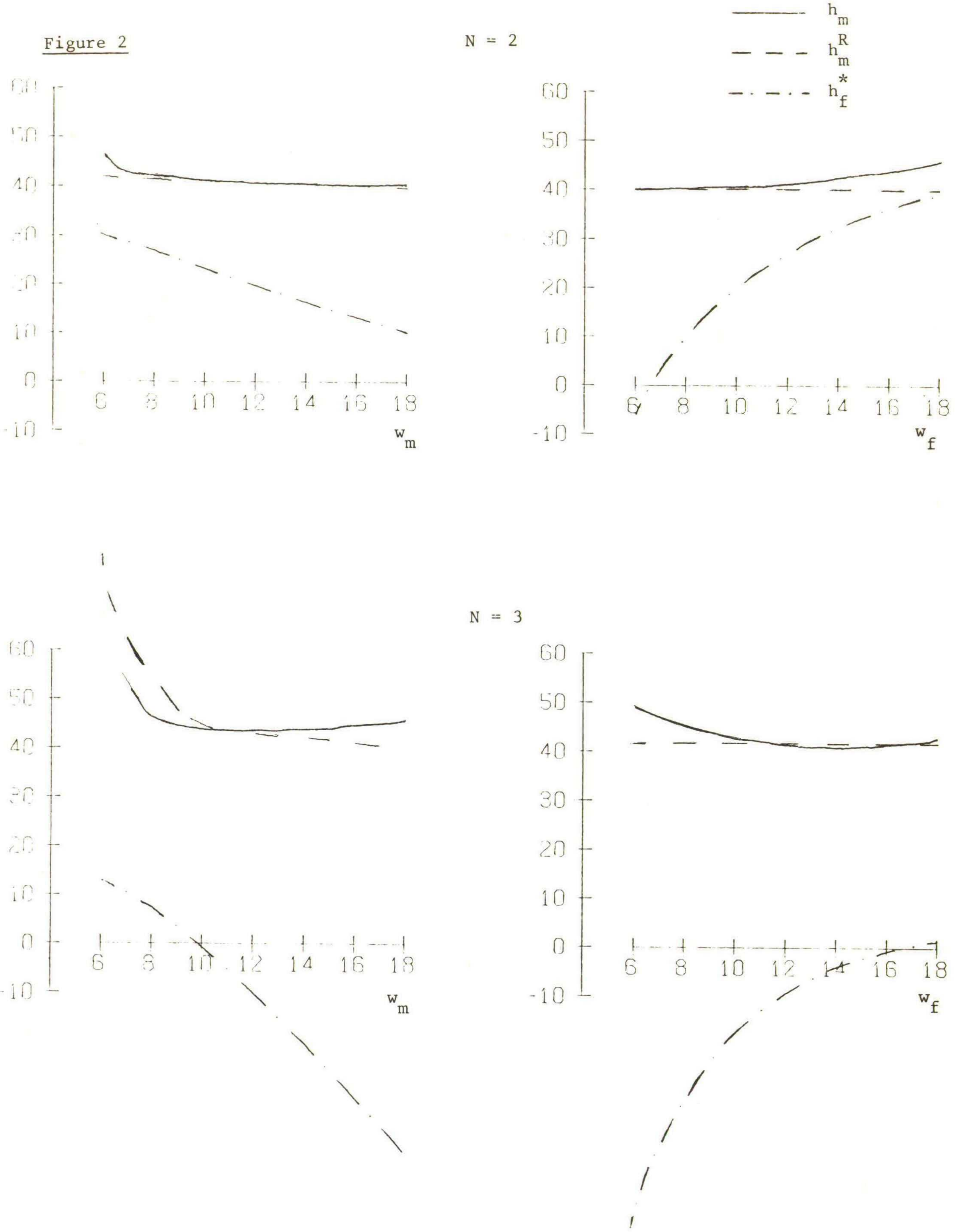
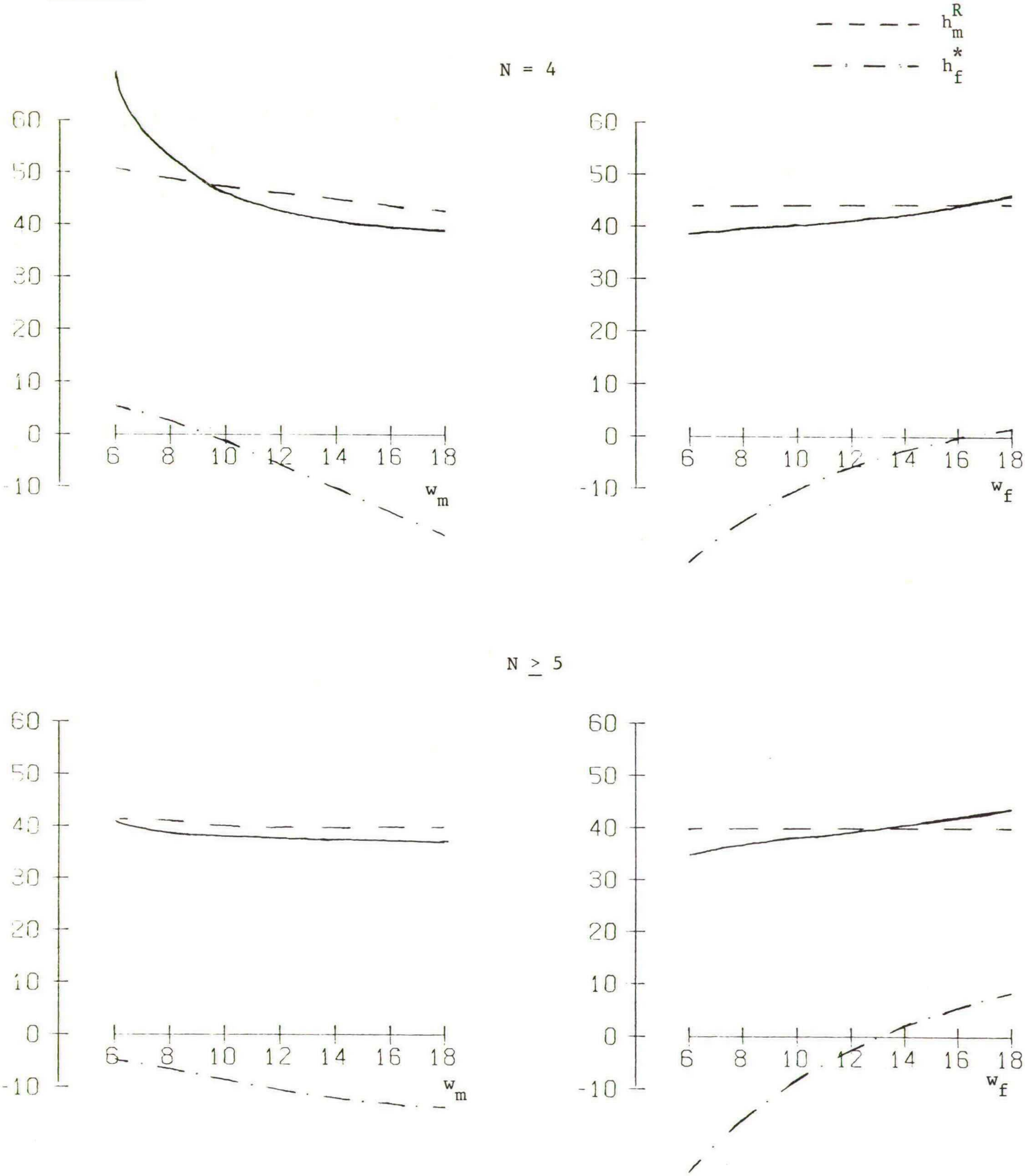


Figure 2 (continued)



Obviously, the highest female participation rate and the largest number of hours worked by the female, occurs in families without children. When there are children, the female participation rate is very low, unless the male wage rate is very low or the female wage rate is very high. In all cases the male labor supply function is rather inelastic.

Finally, we have investigated whether the differences in family composition between the three cases can account for the differences in parameter estimates. We have re-estimated the model for family size 4 for all three cases. The differences between the cases remain significant. (We have not re-estimated the model for other family sizes because the number of observations would in some cases have been very small.) There may be a number of causes for the significant differences. Firstly, it may simply be due to the fact that the participation and hours decision cannot be described within one framework. Secondly, there may be specification errors, e.g. because family composition should be incorporated in a more sophisticated way, or because there are omitted factors. In either case, using data on two earner families only to also model the behavior of one earner households seems to be inappropriate.

6. Concluding remarks

Models of household labor supply are usually estimated using data on two earner families only. This approach is motivated by the fact that the use of data on families with one earner requires the analysis of corner solutions. Although the theory of rationing provides an appropriate framework for the analysis of corner solutions, only restrictive functional specifications allow for a closed form for the utility maximizing labor supply in such cases.

However, using numerical methods, we have estimated a household labor supply model using data on both one earner and two earner families, and using flexible functional forms.

The labor supply functions in figures 1 and 2 look definitely non-linear, indicating the need to use flexible functional forms. The results presented in table 1 indicate, moreover, that for reasons of estimation accuracy it is worthwhile to employ observations on both rationed and unrationed households.

References

Blundell, R. and I. Walker (1982), "Modelling the joint determination of household labour supplies and commodity demands", The Economic Journal, 92, pp. 351-364.

Deaton, A. and J. Muellbauer (1980a), Economics and Consumer Behavior. New York: Cambridge University Press.

- and - (1980b), "An almost ideal demand system", American Economic Review, 70, pp. 312-326.

- and - (1981), "Functional forms for labor supply and commodity demands with and without quantity restrictions", Econometrica, 49, pp. 1521-1532.

Hausman, J.A. (1980), "The effect of wages, taxes and fixed costs on women's labor force participation", Journal of Public Economics, 14, pp. 161-194.

Heckman, J.J. (1974), "Shadow prices, market wages and labor supply", Econometrica, 42, pp. 679-694.

- (1979), "Sample selection bias as a specification error", Econometrica, 47, pp. 153-161.

Lee, L.F. and M.M. Pitt (1983), "Specification and estimation of demand systems with limited dependent variables", Discussion paper, University of Minnesota.

Neary, J.P. and K.W.S. Roberts (1980), "The theory of household behaviour under rationing", European Economic Review, 13, pp. 25-42.

Ray, R. (1982), "Estimating utility consistent labour supply functions", Economics Letters, 9, pp. 389-395.

Zabalza, A. (1983), "The CES utility function, non-linear budget constraints and labour supply. Results on female participation and hours", The Economic Journal, 93, 312-330.

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